LNG INDUSTRY

Managing safe and efficient operations



For facilities that turn pipeline gas into LNG and those that receive LNG for regasification, risks take many forms, but there are multiple solutions, reveals **Laura Chemler, Emerson**.

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) opens its safety guidelines on LNG with the following facts: "LNG takes up 1/600th of the volume of the gaseous state of natural gas, but retains all of the energy potential. Thus, the energy potential of a specific volume of LNG is significantly greater than the same volume of natural gas in its gaseous state."

That high energy density is achieved through cooling the natural gas down to a cryogenic state, a process often referred to as liquefaction. LNG's high density makes it an excellent medium for storing and moving energy from one place to another, typically via ocean transport. This makes LNG a flexible and versatile feedstock for chemical production and electricity generation. As energy demands increase, natural gas-fired power plants offer an effective way of meeting energy needs, while also meeting 2030 clean energy goals.

LNG itself is not flammable, but natural gas is, and wherever there is LNG, there will be some degree of natural gas – either upstream, during liquefaction, or from boil off during storage. This makes risk management an essential part

of running a processing facility, but safety is not the only issue that needs to be managed for optimal operation. A more comprehensive list includes:

- General health, safety, and environment (HSE).
- Politics and regulatory affairs.
- Capacity rights and cargo allocation.
- Credit and financing.
- Gas supply sources.
- Gas price levels.
- General logistics.
- Material compatibility with cryogenic fluids.
- Containment breaches.

These and other factors can impact the viability of an LNG processor. For example, delays in docking schedules can reduce production, and shifts in interest rates can disrupt financing plans. As the demand for LNG continues to increase, it is paramount to minimise overall risk wherever possible. Not all these risks can be solved through better plant operations, but some can, and this article will explore those risk areas and offer practical strategies to mitigate potential problems.

The complexity behind LNG production

LNG production requires much more than just liquefaction (Figure 1), because the main impurities must be removed. They are, in order of importance:

- Water and carbon dioxide (CO_2) because they can freeze solid and damage heat exchangers.
- Hydrogen sulfide (H_2S) and other acids because they can contaminate the main cryogenic heat exchanger.
- Heavier hydrocarbons not essential to meeting the necessary LNG caloric value so they can be separated and distributed to their respective value chains.

The production of LNG is a highly intricate process, involving multiple stages from incoming pipeline reception to final loading. Instrumentation is an important component of effective liquefaction because it collects the data used to control and optimise production. In the subsequent sections, this complex process and associated risks will be broken down, illustrating how all the elements seamlessly integrate.

Many facets of HSE

Looking at HSE requirements, it should be pointed out that the LNG industry overall has had a remarkably high level of safety. LNG has been around for decades, but most facilities are relatively new and have taken advantage of recent technologies and safety practices. Some relate directly to the process, while others are external defences.

Early in the process, the natural gas must be checked for contaminants able to interfere with proper liquefaction. Water vapour must be removed as it freezes at cryogenic temperatures, which is done in the dehydrator prior to liquefaction. A continuous gas analyser quantifies any remaining water in the gas stream, verifying the effectiveness of the dehydrator and alerting the operator to any potential freezing issues downstream (Figure 2).

Contamination must be checked during the process and for custody transfer, where flow measurement is also critical.

Custody transfer

When natural gas comes into a processing facility, there will invariably be a custody transfer point at the pipeline connection, and at the delivery point where LNG is being loaded. Where gas is received, accurate flow measurement and analysis are essential for determining the contractual price determined by the feedstock's energy content. Utilising highly accurate flow metering and analytical systems ensures precise measurement of feed gas composition and flow rates.

The composition of the feed gas will vary based on country and source. For example, feed gas in North America is very different than feed gas in Qatar. Inlet feed gas accuracy measurement is crucial for pricing feedstock correctly as discrepancies can lead to significant financial risk. By also quantifying feed gas composition, these solutions help optimise liquefaction, supporting the plant's efficiency and profitability. Flow meters that can quantify gas composition and provide caloric energy information help to mitigate profitability risk.

Flow measurements between the various processing stages within a facility are also important to look for points where gas volume may be lost or

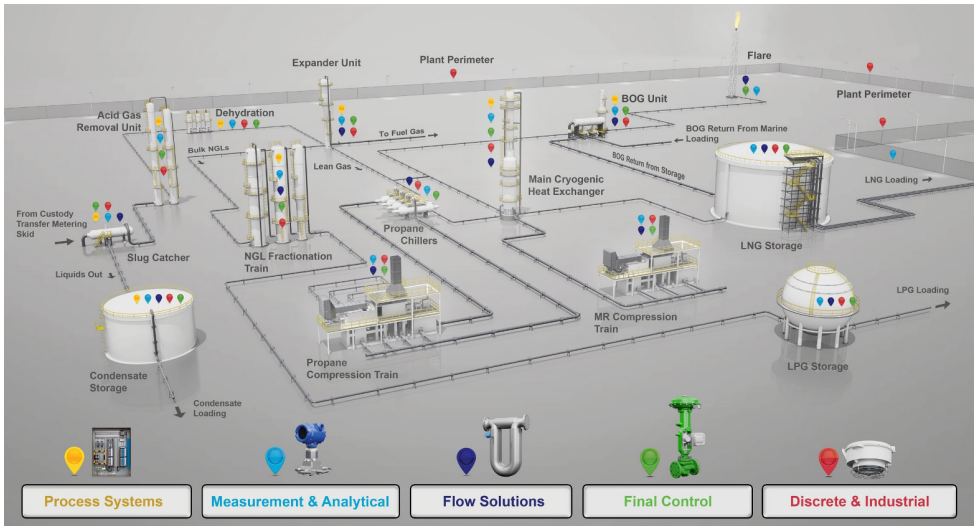

Figure 1. Purification of natural gas prior to liquefaction is the largest part of the process.

process bottlenecks may be developing. Intermediary flow measurements from non-intrusive ultrasonic or Coriolis mass flow meters provide highly accurate measurements in a wide variety of temperature, pressure, and density conditions – for process media in both gaseous and liquid phases.

Accuracy and verification of that accuracy through calibration is paramount in custody transfer. The cost of a drifting calibration or faulty flow measurement can be significant. Having a setup that supports maximum uptime – like a bypass line with a master meter, or having flow meter validation from a secondary flow meter – helps to provide confidence in the custody transfer measurement.

The diameter of natural gas pipelines requires ultrasonic flow meters for custody transfer due to large pipeline sizes. For continuous custody transfer validation through redundancy, a non-intrusive ultrasonic flow meter (Figure 3) can be placed downstream of the custody transfer metering point without interrupting production. With cryogenic compatibility, this non-intrusive flow meter can be used at both the raw gas inlet and at LNG loading for additional validation. Since this non-intrusive flow meter supports Dynamic Gas Master, it can provide molecular mass, operational density, and caloric value – in addition to the volumetric flow rate.

Custody transfer at terminal loading is traditionally done statically in a tank instead of dynamically from a flow measurement. There is no shortage of level technologies to measure the exact volume within the tank from float to servos to radar, however radar technology, like the Rosemount™ 5900S Radar Level Gauge, stands out as the most accurate and reliable method. In addition to proof testing to ensure reliability and accuracy at the terminal custody transfer point, a non-intrusive ultrasonic flow meter with cryogenic capability can be used to validate the total transferred volume.

Custody transfer validation from redundancy improves reliability and plant availability without increasing risk.

During processing, hydrogen sulfide must be removed, which means there will be points in the unit where it is concentrated and stored, presenting a potential health hazard. Fixed-point gas detectors aimed at this highly toxic gas can trigger alarms if a leak is detected. Deploying them is easier when using WirelessHART® connectivity to place them at strategic points around critical equipment.

Throughout the facility, it is necessary to monitor for natural gas leaks because they reduce production and can lead to serious fire and explosion incidents. For risk mitigation, having a layered approach is best as different types of leak detection methodologies look for different types of leaks.

Fixed-point combustible gas detectors are the first approach, and they use one of two technologies. First, catalyst designs respond to an internal chemical reaction driven by hydrocarbon and nonhydrocarbon-based combustible gases. Second, infrared sensors respond to attenuation of specific light frequencies caused by methane and other hydrocarbon gases. Multiple fixed-point detectors are usually deployed where there is a concentration of equipment.

Open-path combustible gas detectors are the second approach, and they send a light beam from a transmitter to a receiver to detect combustible gases moving through the beam. These cover a wider area and are usually deployed like a fence around equipment and tank clusters.



Figure 2. The Rosemount™ X-STREAM Enhanced XEFD Continuous Gas Analyzer can quantify water, and it can also speciate other contaminants, using a combination of NDIR/UV/VIS photometer, paramagnetic and electrochemical oxygen, thermal conductivity, and moisture sensors.



Figure 3. Non-intrusive flow meters (such as Emerson Flexim FLUXUS G736 gas flow meter, shown) provide custody transfer validation at raw gas inlet and cryogenic loading, offering complete assurance of liquefaction plant total input and output.

Gas supply interruptions

Even with the best laid plans, supply chain disruptions can happen. This means LNG processors must control inventory carefully. Generally, final stage storage tanks have sufficient levels to serve as a buffer, but this depends on reliable production. This makes buffer storage critically important to deal with any issues. For example, if there is an interruption to supply reaching the facility, or a lapse in quality control from a supplier resulting in higher contamination levels, production may slow because greater purification is required, or it may stop entirely. On the other hand, if vessels due to receive LNG are delayed, finished LNG production may exceed storage capacity.

Checking quality requires a gas chromatograph (GC), which should be standard equipment for the incoming



Figure 4. Gas chromatograph analysers, such as the Rosemount 470XA Gas Chromatograph, can be field installed without a shelter. It is explosion-proof and ATEX/IECEX safety rated, so it is field installable even in Class 1, Division 1 areas, eliminating the need for costly air-purged enclosures in any environment.



Figure 5. The Rosemount 5900S Radar Level Gauge delivers ±0.5 mm (0.020 in.) instrument accuracy, reducing level measurement uncertainty to a minimum. It provides certified custody transfer accuracy for inventory management and reliable loss control data. It has a two-in-one feature, allowing it to also operate in safety applications as SIL 2 and SIL 3 certified according to IEC 61508, enabling its use in API 2350 compliant solutions.

custody transfer installation at any LNG facility (Figure 4). GC technology is a widely recognised method for composition analysis of natural gas at production and custody transfer points due to its high reliability, measurement accuracy, and low downtime. Tens of thousands of GC analysers are installed worldwide along natural gas pipelines.

A GC analyser separates chemical components within a sample using mass spectrometry, providing a readout of the composition and component quantities. GC software can calculate many critical physical properties of the gas according to industry standards, such as BTU value, Wobbe index, specific gravity, compressibility, and others.

Monitoring inventory of LNG ready to ship calls for a level instrument at the final storage tanks. Due to the cryogenic temperatures involved, a top-mounted radar level gauge (Figure 5) is usually best for this application since it is not necessary for it to contact the liquid. Using a safety certified instrument is critical so it can be integrated with an overfill protection system to avoid spills and releases.

Capacity and cargo risks

Situations over the last year and more have resulted in suppliers unable to meet commitments, or buyers without cargo capacity to transport agreed-upon volumes. Such disputes are rare, but parties on both sides must recognise the possibility.

In these and other cases, custody transfer becomes particularly complex because it is necessary for both sides to monitor loading in real time. LNG's cryogenic nature causes constant volume shrinkage due to boil-off gas (BOG), which must be vented from tanks to avoid over-pressurisation. Effective insulation of all equipment reduces this action, but when loading a vessel, the shore-side custody transfer measurement will be greater than the amount in the tank. Hence the need for high-precision level measurement.

By automating loading processes, operators can ensure that LNG is transferred efficiently, minimising loading times and managing the overall loading process to minimise BOG and protect from overfilling incidents. Additionally, accurate measurement and analysis ensure compliance with trade regulations as LNG is traded based on its energy content. By ensuring precise measurement of energy content, these solutions facilitate fair and accurate practices.

Monitoring at the vessel calls for a high precision radar level instrument, along with additional variables. Some vessels have adopted an approach using a group of instruments to provide a complete solution using level, pressure, and temperature measurement devices capable of operating in cryogenic conditions. A complete multi-instrument single flange solution can be configured to meet the specific requirements of main storage tanks, as well as fuel tanks for LNG-fuelled tankers.

Integrated solutions

The solutions discussed so far sound like they are deployed in isolation. While that is possible, it is far from ideal because they are more effective when integrated into a larger strategy. Emerson serves as a partner to many LNG producers, providing the hardware, software, and general know-how to transform an LNG facility into a fully integrated operation capable of optimising production and minimising risk. These are the capabilities necessary to ensure long-term growth and profitability. **LNG**